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Increasing the students' understanding of the methods of science is often one of the goals of an introductory course in physics for nonscientists. To supplement the examples arising directly from the usual subject matter and to stimulate clearer thought concerning the nature of scientific inquiry, discussion of some subjects which have a surface resemblance to science is proposed. The history of research into extrasensory perception appears to be ideal as such a counterexample, allowing for explicit comparisons which illuminate the subject of methodology in science while maintaining high student interest. Lecture suggestions, including demonstrations, are discussed.

I. PRELUDE

The following question appears at the beginning of a final examination in introductory physics for nonscience students. The reader also is invited to answer the question before proceeding.

Please write, in the spaces provided, the name of one item in each of the following categories:

1. A color . . .
2. A flower . . .
3. A piece of furniture. . .

II. INTRODUCTION

The objectives of a course in introductory physics for nonscience students often require that, in addition to the basic subject matter of physics, an explicit attempt be made to increase the students' awareness of the processes through which scientific knowledge is obtained. While

century world—it is important to also present some counterexamples. A study of the claims and methods of a nonscientific area can provide, by way of contrast, a new perspective in which to view the processes involved in the development and advancement of physics.

Many areas of current interest and controversy may be considered appropriate for the role of "nonscientific counterexample," depending on the inclinations of the instructor and students. *Astrology* is one possibility that can be logically discussed after a study of planetary motions or other astronomical phenomena.^{1,2} *Unidentified flying objects, catastrophic cosmological events* in the recent history of the earth, and related lore could be introduced, similarly, to compare with the nature of physical theory and observation. The subject of *extrasensory perception*, more familiarly known as ESP, has been found to be especially good for this purpose. The remainder of this paper is devoted to providing (a) some background on ESP, with some of the contrasts between its historical development and the methods followed by physicists, and (b) an outline for a lecture on the subject, complete with demonstrations. This lecture format has been used for the past several years; it has never failed to capture the interest of the students and has always generated long and fruitful discussions concerning criteria for evidence, models of reality, and the whole gamut of science methodology.

III. BACKGROUND ON ESP

The subject of ESP has been, historically, a controversial one. A new wave of interest has recently emerged, accompanied by a host of new books and new claims (both of authenticity and of fraud). The recent publication of a study of the phenomena produced by one well-known ESP practitioner, Uri Geller, appearing in a prestigious scientific journal,³ has been countered by articles in the general public media⁴ suggesting where the scientists may have been misled. Photographic studies⁵ of a mysterious "aura" surrounding living objects, said by some to be related to the "thought-transfer" process and by others to be simple, predictable electrostatic effects, have been made with impressively complicated apparatus. All the appearance of conventional scientific investigation is present, and it is truly a challenge to attempt to analyze these new efforts in an old field objectively. However, the interest generated by this revival of ESP research provides an excellent opportunity to introduce the subject in its historical context, and to contrast its development with that of physics.

Background on ESP is often found in the popular press, but the findings of those who reject these studies in the context of the sciences, or of professional "magic,"⁶ are also of interest. An article in linking any definition of ESP to the thought process, and several manifestations of the nonsensory transfer of thought have been given distinctive names:

(i) *Clairvoyance* is usually defined as the ability to have knowledge of events which are taking place in the present, but about which no sensory input can be had.

(ii) *Precognition* is defined as the ability to have

knowledge of events before they happen.

(iii) *Telepathy* is defined as the ability to transfer thoughts directly from one person to another, with no intervening sensory means.

(iv) *Psychokinesis* is defined as an interplay of thoughts and material objects, most often the ability of thought to influence the behavior of an object.

can then the suggestion of the possibility of extrasensory perception probably first arose from a consideration of reports of spontaneously occurring events which, upon reflection, appear to be instances of clairvoyance or precognition. For example, a mother has a "feeling" that her child, in some distant place, is suffering pain; later, she learns that at that moment the child had been involved in an accident and is now hospitalized. Such events seem too real and personal, to those involved, to be dismissed as mere coincidence. Consideration is rarely given to those numerous times when a similar "feeling" turns out to be unrelated to any happening—such occurrences are forgotten at once. Furthermore, the lack of specific details of the actual event in the premonition is usually ignored or even altered in the retelling to indicate a more accurate "vision" than that which may have, in fact, occurred.

Further indications of the existence of an extrasensory facility appeared in the form of demonstrations of apparent telepathic communication. In the late 1800s, scientists reported enthusiastically on exhibitions of telepathy by the four teen-age daughters of a Rev. Andrew Macreight Creary: contents of closed boxes were divined, selected cards named, and selected people's names correctly identified by any of the girls who were out of the room when the selections were made.⁹ Controversy raged, but it was not until many years later that the full truth was revealed: the sisters had been signaling each other through coughs, sniffles, and a variety of subtle body motions. It had all been a joke, but by that time there were dozens of imitators, and thousands of believing spectators, and the ESP movement had begun. (*Scientific American* has a recent note¹⁰ pointing out that, earlier, Michael Faraday spent some time uncovering the deceptions of the so-called psychics of his day, without dissuading any confirmed believers.)

Research into ESP was put into a laboratory setting by J. B. Rhine of Duke University. The most common experiments are conducted with a special set of 25 cards, containing five each of five different symbols: a circle, a cross, a square, three wavy lines, and a star. These cards can be simply turned facedown in a stack; the subject tries to determine what symbol is on each card without seeing the faces (thus testing the subject's clairvoyance and/or precognition). Alternately, one subject (or the experimenter) can look at the cards, one at a time, and attempt to "send" the symbols, via telepathy, to another subject. Tests of psychokinesis are usually performed with dice.

Due to the lack of a theoretical model of the ESP process, performance of any subject on these experiments is ordinarily compared with the null hypothesis, that is, the results to be expected if no special phenomena were occurring. However, the inevitable subjects scoring above one or two standard deviations from the mean expected on a random basis are traditionally subjected to further testing, and some seemingly incredible runs of correct calls have been recorded in this fashion. A high-scoring

subject who later faltered was usually explained by ad hoc "interfering factors" attributed to the delicacy of ESP: tiredness, skeptical observers, etc. Certain subjects were found to be "forward targeting"; that is, their scores were improved if one assumed they were calling the symbols on the card *after* the one in use. Unfortunately, it was never possible to determine in *advance* when forward targeting was taking place. Probabilities were thus used in a somewhat cavalier fashion.

A final shortcoming of these experiments, a throwback to the earliest days of ESP, is the ever present possibility of cheating, either consciously or unconsciously. Tests of various experimenters tended to show that those favorably disposed toward ESP sometimes reported higher scores for a given subject than did skeptical experimenters, and the subjects were often able to cheat directly. Some precautions were taken to reduce this possibility, but, as Dr. Rhine reports,⁶ "Elaborate precautions take their toll" In other words, ESP ability drops, owing to the delicacy of the phenomenon and the sensitivity of the subjects, when precautions against cheating are used. The suggestion that perhaps, in fact, some cheating had been suppressed apparently was not seriously considered.

A final point on the history of ESP should be noted. Throughout the past half-century, professional magicians have often reproduced so-called extrasensory effects by undetectable, but wholly physical methods. While producing an effect by one means does not rule out its production by another, a proper test of ESP must rule out, as far as possible, the clandestine use of any physical process. Often, scientists are not sufficiently versed in the methods of deception to properly rule out certain innocuous-seeming ploys, and employing persons trained in fooling the public as observers might be beneficial. In this regard, it should be noted that Uri Geller, the ESP exponent mentioned earlier, was a nightclub magician before he achieved his present notoriety.

IV. SUGGESTIONS FOR A LECTURE

A lecture on ESP can be based on some of the points made in the previous section. Reading a few quotations at the lecture's opening by those who have experienced particularly dramatic spontaneous "ESP" occurrences sets the mood appropriately. After talking about the early ESP experiments, it is well to do some demonstrations, just as would be done for a discussion of some physical phenomenon. The form of the demonstrations should follow closely, although in a much abbreviated form, the typical experiments done in the past in the search for ESP. At least one experiment should utilize a statistical analysis; the class should be prepared for this from earlier lectures in kinetic theory or atomic structure. A variety of ESP phenomena should be touched on, and one experiment should purposely be done in a manner that seems to rule out "cheating."

The following three demonstrations have been found to work well in this context. All are performed with a standard set of ESP cards.

A. Group experiment in clairvoyance/precognition

The instructor places five cards facedown, one at a time, without looking at their faces. As each is set down, the students write one of the five ESP symbols on a sheet of paper, as their "hunch" for that card. The instructor

then shows the cards, one at a time, and the students note which one they matched properly. The scores of all students are tabulated on the blackboard. These are discussed briefly. In a moderate-sized class, several students will have gotten three out of five correct, which violates the students' sense that one out of five is the best that could be expected; one or more students may have four or five correct. The concept of "forward targeting" can then be introduced, producing a further undervaluation of the scores away from what the random chance expectations are. While comparisons with the true expected random distribution can be made at this time, the atmosphere is heightened in further "evidence" for ESP. It is first presented.

B. Experiment in telepathy

The instructor holds up cards, one at a time, with their faces to the class, asking them all to think of the symbol on that card. The first symbol is correctly called by the instructor, even though he cannot see it. The students are asked to keep score of how well the instructor does—these scores can later be compared to see if any "experimenter bias" has crept in. In this demonstration, the instructor hits on four out of five cards, much to the amazement of the class. Of course, to assure that result, some subterfuge is employed (as explained in the Appendix), but all will be admitted later, during the discussion period.

C. Psychokinesis/clairvoyance effect

Since the possibility that the instructor is "cheating" may come to the students' minds at this point, a third demonstration is done that is apparently out of his hands. One card of each symbol is taken from the set and placed out of sight behind the lecture table. Each of four students is allowed to select one symbol and seal it in an envelope while the instructor is at the back of the room. The envelopes are mixed, and the instructor then proceeds to tear open one envelope at a time, gaze at the symbol, and point out the student that had selected it. After three students have thus been matched with their chosen symbol, only one student remains; the instructor therefore obviously knows which student chose the last symbol. However, he demonstrates a final telepathic flash by naming, instead, the *symbol*, while it is still sealed in the envelope. Again, a page has been taken from the magician's manual, but the effect at that moment is sheer incredulity. The straightforward approach of the physicist demands that the fact that trickery was going on be revealed, but the gullibility of the public in the face of the famous "mind readers" and "clairvoyants" of the past can most easily be appreciated when one has, himself, been "gulled." Any "magic" effects can be employed for these purposes, but those described above have been found to lend themselves particularly well to the ESP format. Their *modus operandi* is described in the Appendix, together with some suggestions on their presentation.

D. Analysis

The demonstrations are now analyzed. A discussion of the expected probabilities for the distribution of correct guesses in the first experiment should be presented, noting the increased chances for success when "forward

Table I. Probabilities for randomly guessing ESP symbols. There are five symbols, and five cards are guessed.

Number guessed correctly	Fraction of population achieving this number	Fraction of population with forward targeting ^a
0	0.33	0.08
1	0.41	0.26
2	0.20	0.35
3	0.05	0.31
4	0.01	0.00
5	0.00	0.00

^aFor forward targeting, the probability of guessing any one correctly goes from 1/5 to 2/5 and the probability of guessing two correctly goes down to 3/5.

targeting" is allowed (see Table I). Trickery on the second experiment is then admitted ("I even have, right here in my lecture notes, 'Get four out of five,' since getting all five would appear too suspicious!"). A list of several possible ways the "cheating" could have been accomplished may be presented: having an assistant among the students sending signals; using a small mirror to catch a glimpse of the faces of the cards; using cards whose backs are marked to indicate the symbol on the front; having a prearranged order to the cards; etc. It is not necessary to reveal which method you actually employed; this list shows how easily the effect could have been achieved. The final "experiment" is also revealed as a fraud, since purely physical means were employed here, too; however, after this disclaimer, leaving the students with one remaining bit of mystery is much more effective than a complete explanation of the method employed.

Following the discussion of the experiment, the comparisons with physical science methodology can be made explicitly. Material from Sec. III can be used as a start in this direction. The analysis can conclude with remarks on some of the current controversial aspects of ESP study, as outlined at the beginning of that section. The recent dismissal¹¹ (for faking experimental results) of the director of the research institute founded by J. B. Rhine may be pointed out as an example of the continuing difficulties of this field of investigation.

V. REPRISE OF PRELUDE

When I wrote the prelude, I was thinking *red, rose, and chair*. What did you write down? Among the *hundreds* of subtle hues, flower varieties, and items of furniture, did you hit any of those I thought of? The vast majority of students having that question on an exam in the past hit at least one; many hit two, and a few even got all three! Is this a demonstration of ESP? Discuss.

APPENDIX: THE "MAGIC SHOW"

The second and third effects suggested as demonstrations for a lecture on ESP are performed by using very simple methods. However, the *mode* of presentation is very important; any similarities between the appearance of these demonstrations and a typical magic show will destroy the atmosphere which is such an important part of the lecture. Thus all words and gestures must be completely natural.

Any of the methods listed in the discussion of the

"telepathy" experiment may, in fact, be employed. However, the simplest by far is to have a subtle method of marking on the backs of the ESP symbol cards. The symbols themselves suggest an easily memorized procedure: the circle is drawn with one stroke; the cross with two; there are three wavy lines; the square has four sides; and the star is five-pointed. Thus, marks representing 1-5, respectively, are needed. In fact, using no mark at all in place of the 5 produces a further simplification.

(Note: Be sure the marks are simple, use an ink which matches the design on the backs of the cards, and mark both ends of each card in any presentation. Be sure not to peel off the back of the card, but glimpse it either before picking it up or when laying it facedown on the table.)

The other effect, guessing correctly which student picked each symbol, is equally simple, although it looks much less possible for the instructor to "cheat." The method depends not on markings on the cards, but rather on markings on the envelopes! Simple fingernail marks on one edge indicate the four envelopes—zero, one, two, and three marks. In order to avoid suspicion, the envelopes are taken to each student, separately, by the instructor as he selects them for the demonstration. He then simply remembers the order the students were chosen, which corresponds exactly to the markings on the envelopes. The instructor can then move on to the back of the room while the students, one at a time (apparently to avoid collusion, but in fact to prevent the exchange of envelopes) select and seal their cards in the envelopes. It is a good precaution always to talk about "the envelope," not "your envelope." After returning to the front and identifying the first three students (in arbitrary

order, of course) by looking at their cards, it is a simple matter to note subtly the unselected symbol card remaining behind the table. Having thus accounted for all but one symbol, that one must be in the fourth student's envelope, and you announce the symbol before tearing open the envelope and showing that you were, indeed, correct.

The effect of the last trick is usually so striking that it would be anticlimactic to explain it. A blanket admission of guilt, of trickery by pure physical means, is enough to remove any feeling that it was done by ESP, while leaving a lasting impression that something special has transpired. The whole lecture will be remembered better, with this bit of residual mystery.

The ever present possibility of creating either consciously or unconsciously

¹M. Zeilik II, *Am. J. Phys.* **42**, 538 (1974); **41**, 961 (1973).

²E. E. Snyder, *Physical Science for Today* (Merrill, Columbus, OH, 1973), Chap. 1.

³R. Targ and H. Puthoff, *Nature* (Lond.) **251**, 602 (1974); see also G. M. Walker, *Electronics* **37**, 82 (7 February 1974).

⁴C. Reynolds and Y. Joel, *Pop. Photogr.* **74**, 74 (1974); see also editorial accompanying publication of Ref. 3, above.

⁵*The Kirlian Aura*, edited by S. Krippner and D. Rubin (Anchor, Garden City, NY, 1974).

⁶J. B. Rhine and J. G. Pratt, *Parapsychology* (Thomas, Springfield, IL, 1957); *Parapsychology, from Duke to FRNM*, edited by J. B. Rhine (Parapsychology, Durham, NC, 1965).

⁷L. Le Shan, *The Medium, the Mystic, and the Physicist* (Viking, New York, 1974).

⁸P. Davidovits, *Communication* (Holt, Rinehart, and Winston, New York, 1972), Appendix II.

⁹M. Christopher, *ESP, Seers and Psychics* (Cromwell, New York, 1970).

¹⁰*Sci. Am.* **232**, 52 (January 1975).

¹¹*Sci. Am.* **231**, 68 (September 1974).

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INTRODUCTION

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students often require that, in addition to the
materials of physics, an explicit attempt be
made to increase students' awareness of the processes
by which scientific knowledge is obtained. While
codifications of these processes under the
name of "scientific method" result in too incom-
plete to be very useful, the experiences of the
students during the course usually provide a
rich source for discussions of the characteristics of
physics. The interplay of observations, experi-
ment, building, deductions, and "accidental" dis-
coveries noted in laboratory sessions, lectures and
historical developments, and all other aspects
of physics. However, if any development of a critical
attitude—such as the ability to sort out what is
important and what is not science in the modern twentieth